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TECHNICAL NOTE

AIR QUALITY IMPACTS OF VARYING INDIVIDUAL TURBINE HORSEPOWER AND HEATER CAPACITIES AT SITES OF PROPOSED NEW SOURCES IN THE PRUDHOE BAY OIL FIELD - ANNUAL ANALYSES (CASES 1, 2, AND 3)

14 January 1980

Submitted to:

SOHIO Petroleum Company
and
ARCO Oil and Gas Company
on behalf of the
Prudhoe Bay Unit Owners

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1.0 INTRODUCTION

In 1978 and 1979 SOHIO Petroleum Company and ARCO Oil and Gas Company submitted to EPA Region X, on behalf of the Prudhoe Bay Unit Owners, three PSD applications. These are entitled:

(1) Prevention of Significant Deterioration Permit Application Submitted by Atlantic Richfield Company and SOHIO Petroleum Company on Behalf of the Prudhoe Bay Unit Owners to the U.S. Environmental Protection Agency for Construction of Additional Facilities at the Prudhoe Bay Oil Field, Prudhoe Bay, Alaska (The 1978 Application)

(2) PSD Permit Application for the Prudhoe Bay Unit Produced Water Injection, Low Pressure Separation and Artificial Lift Projects (The LPS/AL Application)

(3) PSD Permit Application for the Prudhoe Bay Waterflood Project (The Waterflood Application)

As discussed in these applications, additional combustion turbine generated power and process heating capacity will be required at the three SOHIO gathering centers (GC-1, GC-2, and GC-3), at the Central Compressor Plant (CCP), at the SOHIO well pads, and at the three ARCO flow stations (FS-1, FS-2, and FS-3) at Prudhoe Bay. However, in place of some of the specified turbines and heaters proposed for certain facilities*, the Unit

*Facility in this report refers to a particular site of one or more emitting units, which may or may not share a common stack.

Owners may wish to install turbines and heaters that will yield the same total net outputs, but will have different individual ratings in different quantities than those originally proposed. Also, there may be some combining of exhaust systems. The total oxides of nitrogen (NO_x) emissions from each facility, as well as the total power output, will remain unchanged.

The primary purpose of this report is to determine if variations in individual turbine and heater capacities at the aforementioned facilities will cause predicted pollutant concentrations to vary noticeably. The air quality impacts of several such variations have already been presented in the October 1979 report entitled Air Quality Impacts of Varying Individual Turbine Horsepower at Sites of Proposed New Turbine Capacity in the Prudhoe Bay Oil Field. Because it is the pollutant emitted in largest quantity for each unit, NO_x (assumed in this report to be entirely NO_2) was the only pollutant considered. Predicted concentrations are compared in this report on an annual average basis.

The secondary purpose of this report is to determine the change in predicted maximum concentrations which occur when modeling turbine emissions with the full plume rise according to Briggs' equations rather than with 70 percent of the Briggs' value as was done in the previous reports.

Proposed sources refers in this report to those sources for which PSD applications have been submitted to the U. S. Environmental Protection Agency, Region X office, in 1978 and 1979. The existing sources are all other sources within the area of significant impact of the proposed sources, permitted by the Alaska Department of Environmental Conservation as of 1978.

2.0 CASES EXAMINED

The impacts on predicted maximum NO_2 concentrations were calculated for cases or sets of variations in stack characteristics for selected turbines and heaters. For each case maximum concentrations were predicted for two impact areas. One area is that at which the concentration is greatest when all sources are modeled; the other is that at which the concentration is greatest when only the proposed sources are modeled. For all cases except case 3, the 100 MM Btu/hr heater at ARCO's flow station #2 was modeled as two 50-MM Btu/hr heaters. For each case the conservative assumption was made that all emission points (stacks) per facility were collocated. Also, the total NO_2 emission modeled for each source is that listed in the Waterflood Application, regardless of how other stack parameters may be varied for that source.

The three cases modeled are defined below. Table 2-1 lists the selected sources for which stack characteristics were varied for cases 1 and 2 and also lists the basis for the new stack characteristics assigned to these specific sources. Table 2-2 lists the new stack characteristics (stack height, diameter, exit temperature, and flow rate) assigned to the selected sources and referenced in the last column in Table 2-1.

- Case 1 - Maximum annual NO_2 concentrations were predicted. Each turbine proposed in the LPS/AL application rated between 22.6 MHP and 36 MHP was modeled with the stack parameters of a 22.6 MHP turbine with heat recovery. This is a conservative method of representing a larger quantity of turbines which comprise the same total output. Also, the turbines proposed in the 1978 application for SOHIO Gather Centers 2 and 3 were modeled with 22.6 MHP stack parameter.

TABLE 2-1

LIST OF CHANGES TO PROPOSED SOURCES

MODELED IN CASES 1 AND 2*

Location	Equipment	Quantity	Basis for New Stack Characteristics
SOHIO Gathering Center 1	310.5 MM Btu/hr heater	1	22.6 mhp turbine with waste heat recovery**
	42.5 MM Btu/hr heater	2	15 MM Btu/hr heater
SOHIO Gathering Center 2	32.5 MHP turbine	2	22.6 MHP turbine with waste heat recovery
	26.6 MHP turbine	3	22.6 MHP turbine with waste heat recovery
	310.5 MM Btu/hr heater	1	22.6 MHP turbine with waste heat recovery**
	42.5 MM Btu/hr heater	3	15 MM Btu/hr heater
SOHIO Gathering Center 3	17.0 MHP turbine	2	22.6 MHP turbine with waste heat recovery
	310.5 MM Btu/hr heater	1	22.6 MHP turbine with waste heat recovery**
	42.5 MM Btu/hr heater	2	15 MM Btu/hr heater
Central Compressor Plant	25.0 MHP turbine	1	22.6 MHP turbine with waste heat recovery
ARCO Flow Station 1	36.0 MHP turbine	3	22.6 MHP turbine with waste heat recovery
ARCO Flow Station 2	36.0 MHP turbine	4	22.6 MHP turbine with waste heat recovery
ARCO Flow Station 3	36.0 MHP turbine	4	22.6 MHP turbine with waste heat recovery

*Case 3 is not included because it reflects no variations in stack characteristics from the previous PSD applications.

**For Case 2, only, the stack characteristics are based on those of a 25 MM Btu/hr heater.

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TABLE 2-2

STACK CHARACTERISTICS

Equipment (Type of Emitting Unit)	Stack Height (m.)	Stack Diameter (m.)	Exit Temperature (°K)	Exit Velocity (m/sec)
22.6 MHP turbine with waste heat recovery	16.7	1.71	470	50.0
25 MM Btu/hr heater	7.6	0.73	623	10.6
15 MM Btu/hr heater	7.6	0.94	623	10.6

Each 42.5 MM Btu/hr glycol heater was modeled with the stack parameters of a 15 MM Btu/hr heater.

Because they may actually be installed to discharge emissions through turbine stacks, the 310.5 MM Btu heaters were modeled with the 22.6 MHP turbine stack parameters.

The remaining emitting units were modeled with the same stack and NO_x emissions parameters as reported in the Waterflood Application.

- Case 2 - This case is identical to Case 1 except that the 310 MM Btu/hr heaters (one each at Gathering Centers 1, 2, and 3) were modeled with 25 MM Btu/hr stack parameters. This simulated the replacement of each 310 MM Btu/hr heater with twelve 25 MM Btu/hr heaters having separate stacks.

- Case 3 - Maximum annual NO_2 concentrations were predicted. All sources were modeled with the same stack parameters and emissions as appeared in the source listing in the Waterflood Application. However, unlike the LPS/AL and Waterflood Applications, the model predictions were made with full Briggs' plume rise. At EPA Region X's suggestion, the predictions presented in the LPS/AL and Waterfield Applications were based on 70 percent of Briggs' plume rise.

3.0 ANALYTICAL METHODS

The modeling methods discussed in the LPS/AL and Waterflood Applications were those used to predict the annual NO_2 concentrations reported here. The Texas Climatological Model (TCM) was used for annual concentration predictions and concentrations were calculated for rectangular receptor grids with 0.25 km grid spacings. Meteorological inputs to this model consisted of a joint frequency distribution of stability, wind speed and wind direction developed from surface meteorological observations taken at Barter Island, Alaska, for the period 1958-1964. In this modeling exercise all NO_x was assumed to be emitted as or converted to NO_2. In addition, it was assumed for each facility (gathering centers, flow stations, Central Compressor Plant, etc.) that all proposed sources were collocated.

For the modeling analysis a background NO_2 concentration of 1 $\mu g/m^3$ was assumed. For the purposes of this study, the term "background" refers to the contributions to total air quality from all anthropogenic and natural sources outside of or upwind from the Prudhoe Bay area. A discussion of the method used to estimate this background level is presented in the LPS/AL and Waterflood Applications.

4.0 RESULTS

The results of the analyses performed are summarized in Tables 4-1, 4-2, and 4-3. Table 4-1 shows that varying the turbine and heater sizes and exhaust systems as described in Case 1 would not increase the maximum expected annual average NO_2 concentration by more than about 1 $\mu g/m^3$ (or 1.8 percent) above that reported in the Waterflood Application. Because of decreased plume rise, modeling of the 42.5 MM Btu/hr. heater as 15 MM Btu/hr heaters was responsible for most of the increase. Annual concentrations in the area of maximum impact due to proposed sources alone increased by about 10 $\mu g/m^3$ or about 72 percent above those reported in the Waterflood Application. However, the total maximum concentration in this area (25.07 $\mu g/m^3$) is still well below the National Ambient Air Quality Standard for NO_2 of 100 $\mu g/m^3$.

Table 4-2 shows that replacing the 310.5 MM Btu heaters with 25 MM Btu heaters as assumed for Case 2 would increase the maximum annual NO_2 concentration by only about 0.1 $\mu g/m^3$ above the level predicted for Case 1. However, the lower plume rise from the smaller heater units would result in higher concentrations in the area of the maximum impact due to proposed sources alone. Total concentrations in this area due to emissions from all sources increased by about 4 $\mu g/m^3$ or about 16 percent over the level predicted for Case 1.

Table 4-3 illustrates the results of the analysis for Case 3. The modeling of all existing and proposed turbines with 100 percent of Briggs' plume rise, rather than 70 percent, as in the Waterflood Application resulted in a lowering of the maximum annual NO_2 concentration by about 3 $\mu g/m^3$. This corresponds to

TABLE 4-1

MAXIMUM PREDICTED ANNUAL NO_2
CONCENTRATIONS ($\mu g/m^3$) FOR CASE 1*

Pollutant Sources	Concentration at Location of Maximum Impact Due to All Sources	Concentration at Location of Maximum Impact Due to Proposed Sources Alone
Background	1.0	1.0
Existing Sources	66.57	6.54
Proposed Sources	3.37	17.53
Total of All Sources	70.94	25.07

*Case 1 modeled all turbines proposed in the LPS/AL and Waterflood Applications between 22.6 and 36 MHP and the turbines proposed in the 1978 application for Gathering Centers 2 and 3 as 22.6 MHP turbines with heat recovery. The proposed 42.5 MM Btu/hr heaters were modeled with 15 MM Btu heater characteristics, and the proposed 310.5 MM Btu heaters were modeled as if their effluents were discharged through 22.6 MHP turbine stacks.

TABLE 4-2

MAXIMUM PREDICTED ANNUAL NO_2

CONCENTRATIONS ($\mu g/m^3$) FOR CASE 2*

Pollutant Sources	Concentration at Location of Maximum Impact Due to All Sources	Concentration at Location of Maximum Impact Due to Proposed Sources Alone
Background	1.0	1.0
Existing Sources	66.57	6.89
Proposed Sources	3.46	21.17
Total of All Sources	71.03	29.06

*Case 2 is identical to Case 1 except the 310.5 MM Btu heaters were modeled with 25 MM Btu heater stack parameters.

TABLE 4-3

MAXIMUM PREDICTED ANNUAL NO_2

CONCENTRATIONS ($\mu g/m^3$) FOR CASE 3*

Pollutant Sources	Concentration at Location of Maximum Impact Due to All Sources	Concentration at Location of Maximum Impact Due to Proposed Sources Alone **
Background	1.0	1.0
Existing Sources	63.96	4.09
Proposed Sources	1.53	7.93
Total of All Sources	66.49	13.02

*For Case 3 the entire source inventory modeled in the Waterflood Application was modeled but full Briggs' plume rise instead of 70 percent was assumed for the turbines.

** Concentrations reported at location of maximum impact due to proposed sources reported in the LPS/AL and Waterflood Applications. Proposed sources in the 1978 Application not included in determining this location.

an approximate 4.6 percent decrease in maximum annual concentrations below maximum levels reported in the Waterflood Application. Also, concentrations in the area of the maximum impact due to proposed sources alone dropped by about 1.5 $\mu g/m^3$ or about 10 percent.